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(54) **PLUGGABLE ACTIVATION ENGINE  
EXTENSIONS VIA VIRTUAL DISKS**

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claimer.

2002/0100036	A1	7/2002	Moshir et al.	
2005/0149716	A1	7/2005	Nair et al.	
2005/0257214	A1	11/2005	Moshir et al.	
2006/0155735	A1	7/2006	Traut et al.	
2006/0174240	A1	8/2006	Flynn	
2006/0218544	A1*	9/2006	Chakraborty et al.	717/168
2007/0094348	A1	4/2007	Scheidel et al.	
2008/0256534	A1*	10/2008	Chess et al.	718/1
2008/0270583	A1	10/2008	Gonzalez et al.	
2009/0007105	A1	1/2009	Fries et al.	
2009/0094576	A1	4/2009	Bouchard et al.	
2009/0172662	A1	7/2009	Liu	
2009/0260007	A1	10/2009	Beaty et al.	
2009/0282404	A1	11/2009	Khandekar et al.	
2009/0300604	A1*	12/2009	Barringer	717/178
2009/0320014	A1	12/2009	Sudhakar	
2009/0328030	A1	12/2009	Fries	
2010/0058327	A1*	3/2010	Dehaan	717/176
2011/0029966	A1	2/2011	Moshir et al.	
2011/0093849	A1*	4/2011	Chawla et al.	718/1

(Continued)

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CPC . **G06F 8/63** (2013.01); **G06F 8/65** (2013.01);  
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(2013.01)

(58) **Field of Classification Search**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

6,393,560 B1 5/2002 Merrill et al.  
7,293,168 B2 11/2007 Maeda et al.

#### OTHER PUBLICATIONS

Smith, J.; Nair, R., "Virtual Machines: Versatile Platforms for  
Systems and Processes" (Jun. 3, 2005), Morgan Kaufmann Pub-  
lishers, pp. 1-611.\*

(Continued)

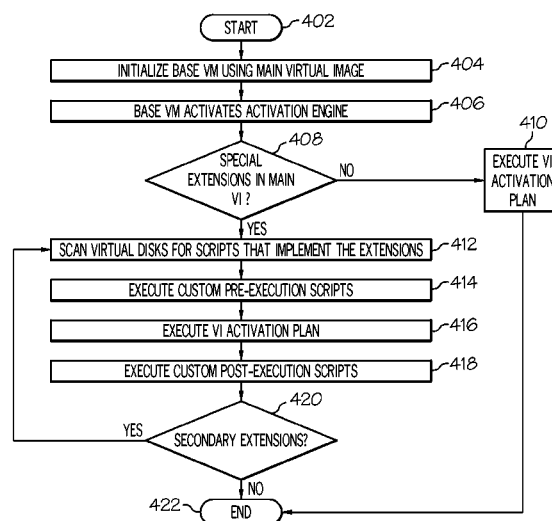
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(57) **ABSTRACT**

A computer-implemented method, system and/or computer  
program product configure an extended virtual machine. A  
virtual image is executed to initialize a virtual machine. An  
activation engine is activated to search for special extensions  
in the virtual image. The virtual machine scans at least one  
virtual disk for script to implement the special extensions as  
virtual machine extensions, such that the virtual machine  
reads and executes the extensions prior to being available for  
use.

**12 Claims, 4 Drawing Sheets**



(56)

**References Cited**

**U.S. PATENT DOCUMENTS**

2011/0197188 A1\* 8/2011 Srinivasan et al. .... 718/1  
2011/0213875 A1 9/2011 Ferris et al.

**OTHER PUBLICATIONS**

Rittinghouse, J.; Ransome, J., "Cloud Computing: Implementation, Management, and Security" (Aug. 17, 2009), CRC Press, pp. 1-296.\*

Hess, K.; Newman, A., "Practical Virtualization Solutions: Virtualization from the Trenches", (Oct. 22, 2009), pp. 1-24.\*

Schwarzkopf, R.; Schmidt, M.; Fallenbeck, N.; Freisleben, B., "Multi-layered Virtual Machines for Security Updates in Grid Environments," (Aug. 27-29, 2009), 35th Euromicro Conference on Software Engineering and Advanced Applications, pp. 563-570 [retrieved from <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5350011&isnumber=5349835>].\*

Nolan, J.; Nolan-Haley, J.; Connolly, M.J.; Hicks, S.; Alibrandi, M., Black's Law Dictionary (1990), p. 979.\*

Wikipedia, "INIT", Mar. 7, 2010, pp. 1-4, <http://en.wikipedia.org/w/index.php?title=Init&oldid=348349356>.

S. Yamasaki et al., "Model-Based Resource Selection for Efficient Virtual Cluster Deployment", Virtualization Technology in Distributed Computing, 2007, Second International Workshop on, ACM, Piscataway, NJ, USA, Nov. 12, 2007, pp. 1-7.

International Searching Authority, International Search Report and Written Opinion for International Application No. PCT/EP2011/055547, Mailed Jul. 7, 2011, pp. 1-15.

Foster et al., "Virtual Clusters for Grid Communities", Sixth IEEE International Symposium on Cluster Computing and the Grid, pp. 513-520, May 16, 2006.

U.S. Appl. No. 13/417,113—Non-Final Office Action Mailed May 19, 2014.

U.S. Appl. No. 13/417,113—Notice of Allowance Mailed Aug. 8, 2014.

T. Chieu et al., "Dynamic Scaling of Web Applications in a Virtualized Cloud Computing Environment", IEEE, International Conference on e-Business Engineering, 2009, pp. 281-286.

\* cited by examiner

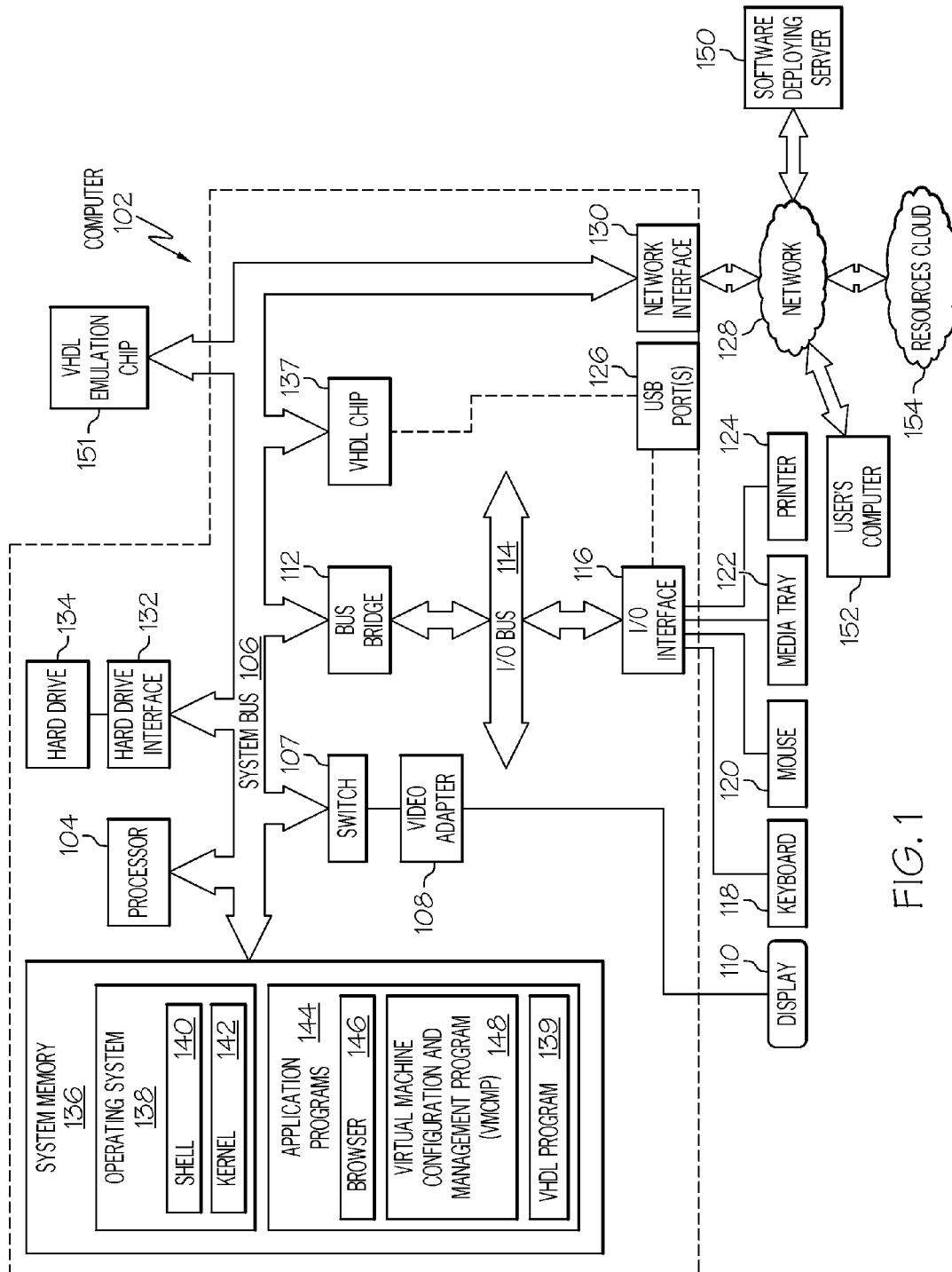


FIG. 1

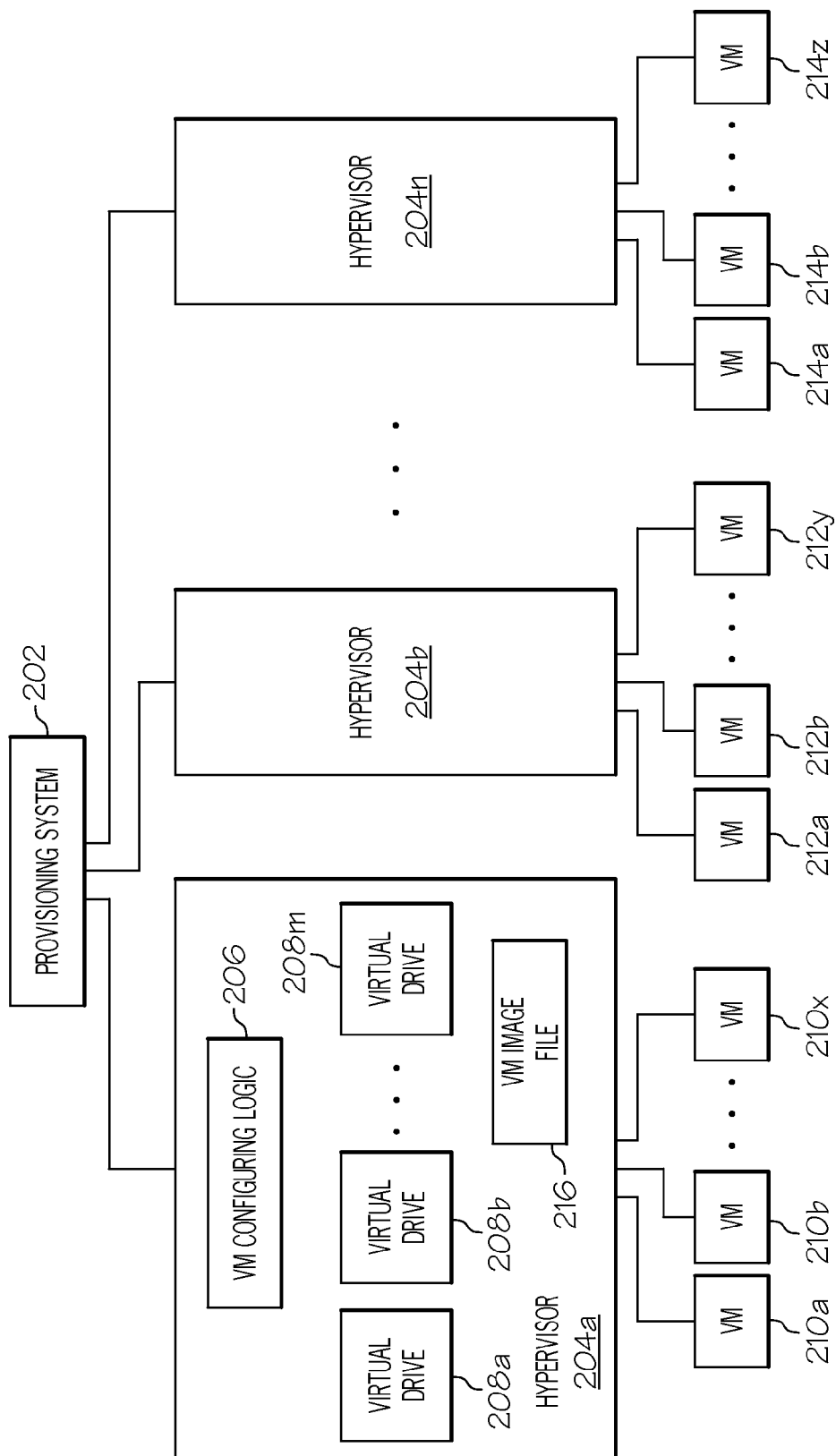


FIG. 2

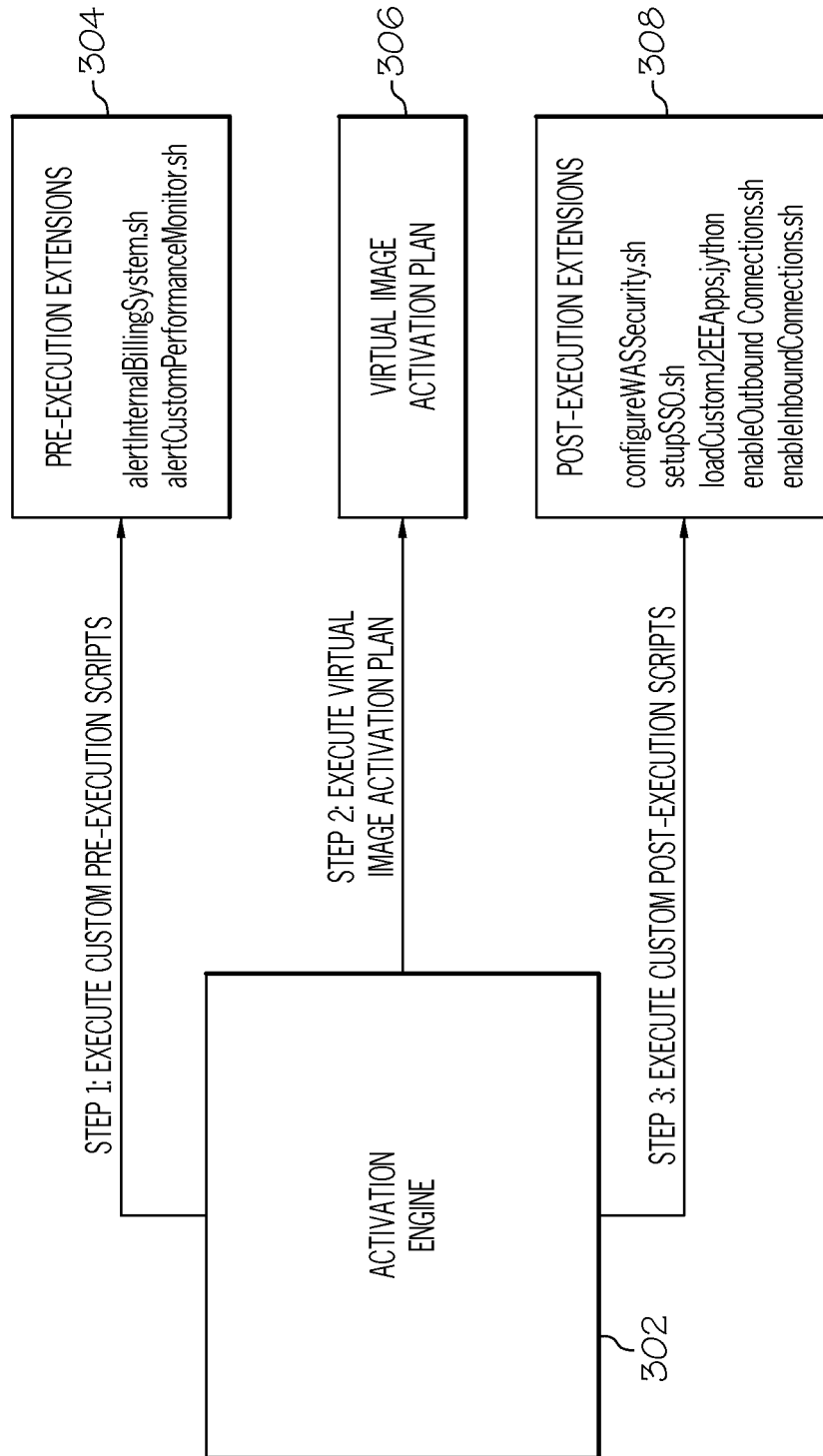


FIG. 3

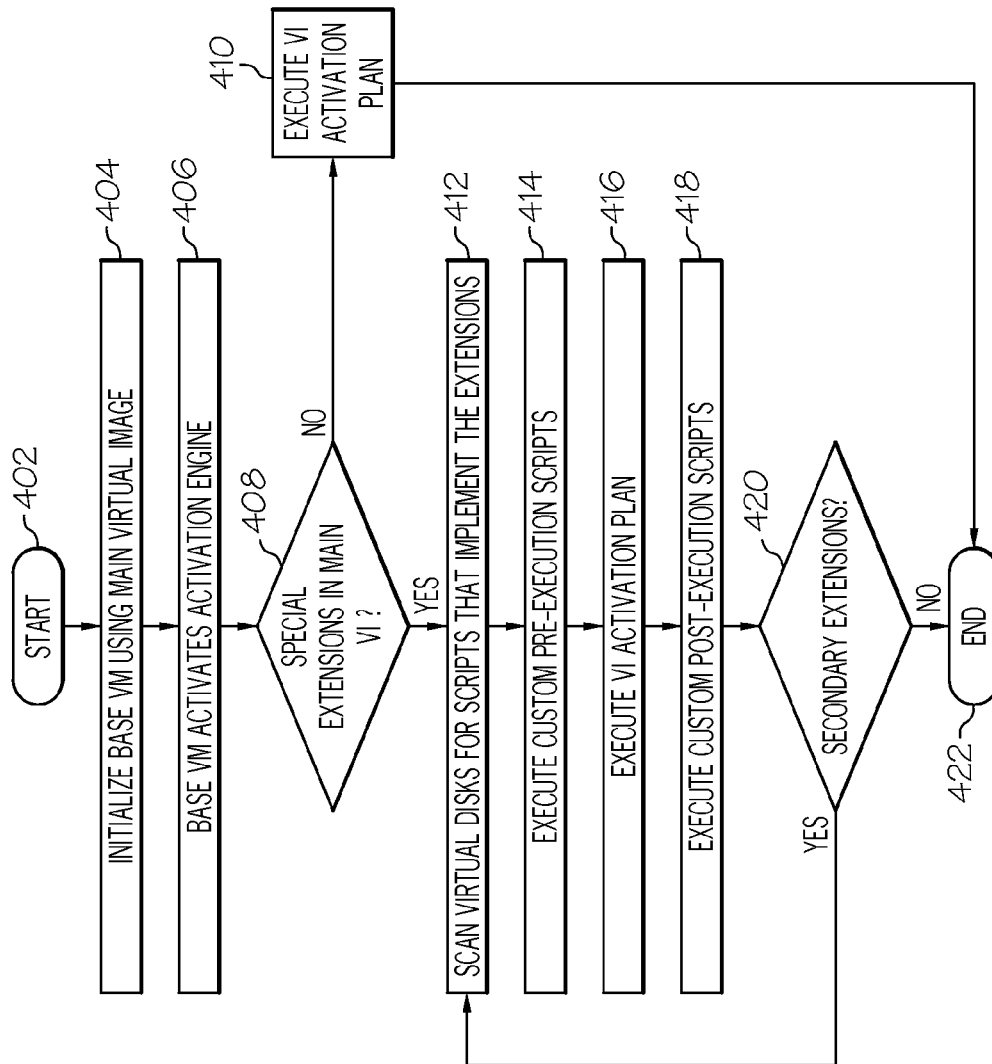


FIG. 4

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## PLUGGABLE ACTIVATION ENGINE EXTENSIONS VIA VIRTUAL DISKS

### BACKGROUND

The present disclosure relates to the field of computers, and specifically to virtual computing devices. Still more particularly, the present disclosure relates to configuring virtual computing devices.

### BRIEF SUMMARY

A computer-implemented method, system and/or computer program product configure an extended virtual machine. A virtual image is executed to initialize a virtual machine. An activation engine is activated to search for special extensions in the virtual image. The virtual machine scans at least one virtual disk for script to implement the special extensions as virtual machine extensions, such that the virtual machine reads and executes the extensions prior to being available for use.

### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. 1 depicts an exemplary computer in which the present disclosure may be implemented;

FIG. 2 illustrates an exemplary environment in which virtual machines are configured and managed during operation;

FIG. 3 depicts an activation engine configuring an extended virtual machine in accordance with one embodiment of the present disclosure; and

FIG. 4 is a high level flow chart of one or more exemplary steps performed by a processor to configure an extended virtual machine.

### DETAILED DESCRIPTION

As will be appreciated by one skilled in the art, the present disclosure may be embodied as a system, method or computer program product. Accordingly, the present disclosure may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “circuit,” “module” or “system.” Furthermore, the present disclosure may take the form of a computer program product embodied in one or more computer-readable medium(s) having computer-readable program code embodied thereon.

Any combination of one or more computer-readable medium(s) may be utilized. The computer-readable medium may be a computer-readable signal medium or a computer-readable storage medium. A computer-readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer-readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any

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suitable combination of the foregoing. In the context of this document, a computer-readable storage medium may be any tangible medium that can contain or store a program for use by or in connection with an instruction execution system, apparatus, or device.

A computer-readable signal medium may include a propagated data signal with computer-readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electromagnetic, optical, or any suitable combination thereof. A computer-readable signal medium may be any computer-readable medium that is not a computer-readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

Program code embodied on a computer-readable medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

With reference now to the figures, and in particular to FIG. 1, there is depicted a block diagram of an exemplary computer 102, which may be utilized by the present disclosure. Note that some or all of the exemplary architecture, including both depicted hardware and software, shown for and within computer 102 may be utilized by software deploying server 150 and/or user's computer 152.

Computer 102 includes a processor unit 104 that is coupled to a system bus 106. Processor unit 104 may utilize one or more processors, each of which has one or more processor cores. A video adapter 108, which drives/supports a display 110, is also coupled to system bus 106. In one embodiment, a switch 107 couples the video adapter 108 to the system bus 106. Alternatively, the switch 107 may couple the video adapter 108 to the display 110. In either embodiment, the switch 107 is a switch, preferably mechanical, that allows the display 110 to be coupled to the system bus 106, and thus to be functional only upon execution of instructions (e.g., virtual machine configuration and management program—VMCMP 148 described below) that support the processes described herein.

System bus 106 is coupled via a bus bridge 112 to an input/output (I/O) bus 114. An I/O interface 116 is coupled to I/O bus 114. I/O interface 116 affords communication with various I/O devices, including a keyboard 118, a mouse 120, a media tray 122 (which may include storage devices such as CD-ROM drives, multi-media interfaces, etc.), a printer 124, and (if a VHDL chip 137 is not utilized in a manner described below), external USB port(s) 126. While the format of the ports connected to I/O interface 116 may be any known to those skilled in the art of computer architecture, in a preferred embodiment some or all of these ports are universal serial bus (USB) ports.

As depicted, computer 102 is able to communicate with a software deploying server 150, user's computer 152 and/or resources cloud 154 via network 128 using a network interface 130. Network 128 may be an external network such as the Internet, or an internal network such as an Ethernet or a virtual private network (VPN).

A hard drive interface 132 is also coupled to system bus 106. Hard drive interface 132 interfaces with a hard drive 134. In a preferred embodiment, hard drive 134 populates a system memory 136, which is also coupled to system bus 106. System memory is defined as a lowest level of volatile memory in computer 102. This volatile memory includes additional higher levels of volatile memory (not shown), including, but not limited to, cache memory, registers and

buffers. Data that populates system memory **136** includes computer **102**'s operating system (OS) **138** and application programs **144**.

OS **138** includes a shell **140**, for providing transparent user access to resources such as application programs **144**. Generally, shell **140** is a program that provides an interpreter and an interface between the user and the operating system. More specifically, shell **140** executes commands that are entered into a command line user interface or from a file. Thus, shell **140**, also called a command processor, is generally the highest level of the operating system software hierarchy and serves as a command interpreter. The shell provides a system prompt, interprets commands entered by keyboard, mouse, or other user input media, and sends the interpreted command(s) to the appropriate lower levels of the operating system (e.g., a kernel **142**) for processing. Note that while shell **140** is a text-based, line-oriented user interface, the present disclosure will equally well support other user interface modes, such as graphical, voice, gestural, etc.

As depicted, OS **138** also includes kernel **142**, which includes lower levels of functionality for OS **138**, including providing essential services required by other parts of OS **138** and application programs **144**, including memory management, process and task management, disk management, and mouse and keyboard management.

Application programs **144** include a renderer, shown in exemplary manner as a browser **146**. Browser **146** includes program modules and instructions enabling a world wide web (WWW) client (i.e., computer **102**) to send and receive network messages to the Internet using hypertext transfer protocol (HTTP) messaging, thus enabling communication with software deploying server **150** and other described computer systems.

Application programs **144** in computer **102**'s system memory (as well as software deploying server **150**'s system memory) also include a virtual machine configuration and management program (VMCMP) **148**. VMCMP **148** includes code for implementing the processes described below, including those described in FIGS. 2-4. In one embodiment, computer **102** is able to download VMCMP **148** from software deploying server **150**, including in an on-demand basis, such that the code from VMCMP **148** is not downloaded until runtime or otherwise immediately needed by computer **102**. Note further that, in one embodiment of the present disclosure, software deploying server **150** performs all of the functions associated with the present disclosure (including execution of VMCMP **148**), thus freeing computer **102** from having to use its own internal computing resources to execute VMCMP **148**.

Also stored in system memory **136** is a VHDL (VHSIC hardware description language) program **139**. VHDL is an exemplary design-entry language for field programmable gate arrays (FPGAs), application specific integrated circuits (ASICs), and other similar electronic devices. In one embodiment, execution of instructions from VMCMP **148** causes VHDL program **139** to configure VHDL chip **137**, which may be an FPGA, ASIC, etc.

In another embodiment of the present disclosure, execution of instructions from VMCMP **148** results in a utilization of VHDL program **139** to program a VHDL emulation chip **151**. VHDL emulation chip **151** may incorporate a similar architecture as described herein for VHDL chip **137**. Once VMCMP **148** and VHDL program **139** program VHDL emulation chip **151**, VHDL emulation chip **151** performs, as hardware, some or all functions described by one or more executions of some or all of the instructions found in

VMCMP **148**. That is, the VHDL emulation chip **151** is a hardware emulation of some or all of the software instructions found in VMCMP **148**. In one embodiment, VHDL emulation chip **151** is a programmable read only memory (PROM) that, once burned in accordance with instructions from VMCMP **148** and VHDL program **139**, is permanently transformed into a new circuitry that performs the functions needed to perform the process described below in FIGS. 2-4.

Resources cloud **154** supports cloud computing, in which software and hardware resources are shared. In one embodiment, the virtual disks and/or virtual machines described herein reside within the resources cloud **154**, which is supported by multiple physical machines (not shown).

The hardware elements depicted in computer **102** are not intended to be exhaustive, but rather are representative to highlight essential components required by the present disclosure. For instance, computer **102** may include alternate memory storage devices such as magnetic cassettes, digital versatile disks (DVDs), Bernoulli cartridges, and the like. These and other variations are intended to be within the spirit and scope of the present disclosure.

With reference now to FIG. 2, an exemplary environment in which extended virtual machines (EVMs) are configured and managed during operation in accordance with one embodiment of the present disclosure is presented. A provisioning system **202**, which may reside on a computer such as computer **102** shown in FIG. 1, supervises operations of multiple hypervisors **204a-n** (where "n" is an integer). Through the use of virtual machine (VM) configuring logic **206** and virtual drives **208a-m** (where "m" is an integer"), both of which may be part of VMCMP **148** described above, hypervisor **204a** is able to configure, manage and operate multiple VMs **210a-x** (where "x" is an integer). Note that hypervisor **204b** and hypervisor **204n** have a similar construction as hypervisor **204a**, and are respectively able to configure, manage and operate multiple VMs **212a-y** (where "y" is an integer) and multiple VMs **214a-z** (where "z" is an integer). In accordance with one embodiment of the present disclosure, when one of the VMs **210a-x** is extended into an extended VM (as described herein), a complete image of that extended VM need not be transferred to the VM image file **216** in the hypervisor **204a**. Rather, only a main VM image file and tags to extensions need be stored in the VM image file **216**.

Note that provisioning system **202**, hypervisors **204a-n**, and/or all VMs shown in FIG. 2 may reside in computer **102**, resources cloud **154**, and/or be distributed between the computer **102** and resources cloud **154** shown in FIG. 1.

With reference now to FIG. 3, assume that an activation engine **302**, which may reside in any hypervisor depicted in FIG. 2, is assigned the duty of implementing an extended virtual machine (EVM). As understood by those skilled in the art of computers, a virtual machine (VM) is a software simulation of a physical computer. Such a VM is able to handle all processes that a physical computer can perform, including storing data, executing instructions, transmitting data across networks, busses, etc. As shown in Step 1 of FIG. 3, the activation engine **302** first executes any custom pre-execution scripts found in an extended virtual image file. An extended virtual image file is a set of instructions that provides instructions for configuring an extended virtual machine. The extended virtual machine includes a main virtual machine, as well as virtual machine extensions. Before creating the main virtual machine, however, pre-execution extensions **304** are run. Execution of such pre-execution extensions **304** can result in establishing billing systems used to charge a user (e.g., the user of user computer



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152 shown in FIG. 1) that requested the extended virtual machine (EVM). This billing can be based on the length of time that the EVM is operational, the number of transactions executed by the EVM, the specific abilities (e.g., processing power, transmission bandwidth, memory, etc.) of the EVM, etc. In addition, the pre-execution extensions can result in establishing a custom performance monitor that monitors the activities (e.g., through a dashboard) of the EVM. A billing system and/or custom performance monitor are examples of customization that can be incorporated into the EVM, and should not be construed as being a limited listing of such customizations.

As describe in Step 2, a virtual image activation plan 306 can then be executed to configure the main VM, which along with the virtual machine extensions created by pre-execution extensions 304 and post-execution extensions 308 form the EVM. As described in Step 3, executing the custom post-execution extensions 308 results in additional virtual machine extensions, including security systems (e.g., password protection, encryption, etc.) for the EVM, single sign on (SSO) setup (allowing a single user to sign on to and use multiple EVMs), and the creation of inbound and outbound connections (e.g., virtual ports) to the EVM. Note that pre-execution extensions 304, virtual image activation plan 306, post-execution extensions 308, as well as the main virtual image used to initialize the main virtual machine can be stored in the virtual drives (e.g., 208a-m) located in the hypervisors (e.g., 204a) shown in FIG. 2. Note also that calling the extensions, and thus extending the VM, is performed by the main VM, such that the main VM is able to self-extend/customize itself.

With reference now to FIG. 4, a high level flow chart of one or more exemplary steps performed by a processor to configure an extended virtual machine is presented. After initiator block 402, which may be prompted by a user of user computer 152 shown in FIG. 1 requesting that an extended virtual machine (EVM) be configured, a main virtual machine is initialized using a main virtual image (block 404). This “main virtual machine” can be viewed as a “backbone” of the EVM, which is then extended by the pre and/or post extensions described herein by activating (block 406) the activation engine 302 shown in FIG. 3. This activation engine 302, which in one embodiment is part of the main virtual machine, then checks for any special extensions in the main virtual image (query block 408). If there are no such special extensions in the main virtual image (VI), then the VM is activated as a non-extended (traditional) VM (block 410) and the process ends (terminator block 422). However, if there are special extensions in the main VI (query block 408), then the base VM scans/searches through multiple virtual disks (block 412) to locate a script needed to implement the special extensions as virtual machine extensions. Thereafter, the pre-execution scripts are executed (block 414), the main VI activation plan is executed to create the main VM (block 416), and the post-execution scripts are executed (block 418). The script execution described in blocks 414-418 results in the complete EVM being configured and deployed.

As described in query block 420, there may be occasions in which one virtual disk must call on another virtual disk for the desired extension. If so, then these “secondary extensions” are called from a second virtual disk by the first virtual disk, such that several extensions can be chained together and executed sequentially (block 412).

The flowchart and block diagrams in the figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer pro-

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gram products according to various embodiments of the present disclosure. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of various embodiments of the present disclosure has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the disclosure in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the disclosure. The embodiment was chosen and described in order to best explain the principles of the disclosure and the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

Note further that any methods described in the present disclosure may be implemented through the use of a VHDL (VHSIC Hardware Description Language) program and a VHDL chip. VHDL is an exemplary design-entry language for Field Programmable Gate Arrays (FPGAs), Application Specific Integrated Circuits (ASICs), and other similar electronic devices. Thus, any software-implemented method described herein may be emulated by a hardware-based VHDL program, which is then applied to a VHDL chip, such as a FPGA.

Having thus described embodiments of the disclosure of the present application in detail and by reference to illustrative embodiments thereof, it will be apparent that modifications and variations are possible without departing from the scope of the disclosure defined in the appended claims.

What is claimed is:

1. A computer program product for configuring an extended virtual machine, the computer program product comprising:

a computer readable storage media;

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first program instructions to execute a main virtual image to initialize a main virtual machine;

second program instructions to activate an activation engine to search for special extensions in the main virtual image; and

third program instructions to scan at least one virtual disk for script to implement the special extensions as virtual machine extensions, wherein the main virtual machine and the virtual machine extensions combine to configure an extended virtual machine; and wherein the first, second and third program instructions are stored on the computer readable storage media.

2. The computer program product of claim 1, wherein the virtual machine extensions comprise pre-execution extensions that are implemented before the main virtual machine is configured.

3. The computer program product of claim 2, wherein the pre-execution extensions configure a billing system and a performance monitor for the extended virtual machine.

4. The computer program product of claim 1, wherein the virtual machine extensions comprise post-execution extensions that are implemented after the main virtual machine is configured.

5. The computer program product of claim 4, wherein the post-execution extensions configure security, single sign on (SSO) setup, inbound connections and outbound connections for the extended virtual machine.

6. A computer system comprising:

a central processing unit (CPU), a computer readable memory, and a computer readable storage media;

first program instructions to execute a main virtual image to initialize a main virtual machine;

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second program instructions to activate an activation engine to search for special extensions in the main virtual image; and

third program instructions to scan at least one virtual disk for script to implement the special extensions as virtual machine extensions, wherein the main virtual machine and the virtual machine extensions combine to configure an extended virtual machine; and wherein the first, second and third program instructions are stored on the computer readable storage media for execution by the CPU via the computer readable memory.

7. The computer system of claim 6, wherein the virtual machine extensions comprise pre-execution extensions that are implemented before the main virtual machine is configured.

8. The computer system of claim 7, wherein the pre-execution extensions configure a billing system and a performance monitor for the extended virtual machine.

9. The computer system of claim 6, wherein the virtual machine extensions comprise post-execution extensions that are implemented after the main virtual machine is configured.

10. The computer system of claim 9, wherein the post-execution extensions configure security, single sign on (SSO) setup, inbound connections and outbound connections for the extended virtual machine.

11. The computer system of claim 6, wherein said at least one virtual disk resides in a hypervisor that configures the extended virtual machine.

12. The computer system of claim 6, wherein the extended virtual machine is part of a computer cloud of resources.

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